RP 203 Generator Off-Line Electrical Testing

The following recommended practice (RP) is subject to the disclaimer at the front of this manual. It is important that users read the disclaimer before considering adoption of any portion of this recommended practice.

This recommended practice was prepared by a committee of the AWEA Operations and Maintenance (O&M) Committee.

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Purpose and Scope

The scope of "Generator Off-Line Electrical Testing" provides an introduction to basic electrical tests for the periodic testing and troubleshooting of wind turbine generator electrical circuits. It is not intended to provide specific techniques or recommendations for corrections based on the test results.

Introduction

All generators, regardless of their design, contain at least one wound element where most or all of the energy is generated and made available to the system. They are often complicated windings with many opportunities for weakness, as well as many connections where high resistance is a concern. When most electrical failures occur, a generator specialist is required for correction or repair, but normal operating conditions can often be verified by normal maintenance staff.

Some electrical tests are designed to merely provide a high level of confidence that the machine can be energized safely, but not as predictive tools regarding the longevity of the windings or even their performance under full load. Higher level testing can safely stress the winding insulating at or above normal operation levels and can help develop trends for predictive maintenance.

On-line electrical testing can provide a large amount of useful information, but specialized equipment and training is critical and the parameters for use on wind turbine generators is not yet available as standard testing. Future editions of this standard should address this technology as it develops.

This guide will provide an introduction to several of these tests, but only the insulation resistance testing is recommended for use by non-specialized personnel. Always remember the dangers associated with any electrical testing and follow proper safety procedures. Qualified and accredited companies and technicians should be utilized in most cases. Reference NFPA 70B and NFPA 70E as well as the InterNational Electrical Testing Association (NETA)/ANSI testing protocols.

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Generator Off-Line Electrical Testing

1. Common Test Methods

1.1. Insulation Resistance

Insulation resistance testing (sometimes referred to as IR testing, not to be confused with infrared testing) is one of the oldest maintenance procedures developed for the electrical industry and is covered in detail in IEEE Standard 43-2000. This test is fairly simple to perform and can provide information regarding the condition of the electrical insulation in the generator as well as contamination and moisture. This test is recommended before energizing a machine that has been out-of-service or where heating elements have failed to keep the winding temperature above the dew point, which might have resulted in condensation on the windings. It is also useful whenever there is doubt as to the integrity of the windings and before any over voltage testing is performed. An accurate IR test requires a correction factor for the winding temperature to create useful data. The methods and expected resulting data for this test is listed in the standard document. While the test results from IR testing are not normally trended, it is possible to do so to show a gross degradation of the insulation systems. It is, however, very important that the duration of the test, the temperature of the windings and relative humidity be consistent for the trend data to be meaningful.

1.2 Polarization Index

Another test described in IEEE Standard 43-2000 is the polarization index, or P.I., that is useful in some applications to identify contaminated and moist windings. In most modern machines, however, where the insulation resistance is above 5000 megohms the test might not prove meaningful. There has also been a consideration of collecting de-polarization data. Refer to the standards document for additional applications and details.

1.3. Winding Resistance Testing

It is common to use a basic ohmmeter in screening generator winding circuits, but the information gained is not a reliable diagnostic tool because of the many components in the circuit. The use of very low resistance test meters can provide good information, but these tests are very sensitive to temperature fluctuations and trending is difficult.

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1.4. Ancillary Component Tests

Testing any auxiliary motors such as those in cooling systems or automated lubrication devices would follow the same basic procedures as the generator itself, but at the appropriate testing range. Other components such as resistance thermal devices (RTD), thermocouples, heater elements, micro switches, etc., are normally checked with an ohmmeter. Consult the manufacturer's literature for specifications.

2. High Voltage Tests

Although these tests are not commonly used in general maintenance procedures, it is useful to have a basic understanding of what tests are available for predictive maintenance trending, troubleshooting, and failure analysis. These tests are generally considered to be non-destructive in nature, but a weakness in the insulation system could and probably should fail during these tests so care should be taken when determining when these tests are advisable. It is recommended that only properly trained generator electrical test technicians should perform these tests.

2.1. High Potential Testing

The high potential test, sometimes referred to as an over potential test, is designed to stress the electrical insulation beyond its normal operating voltages to expose potential failures at a more convenient time. Both AC and DC tests are available, but should only be performed by a generator testing expert. The DC test methods are described in IEEE Standard 95. Trending is possible with this testing, but care should be taken as insulation weaknesses (cracking, contamination, carbon tracking, etc.) can be advanced to failure.

2.2. Step Over-Voltage Test

Using the same equipment as the high potential test, the step over-voltage test stresses the insulation at rising levels of voltage over a set time scale. This is a very useful trending test and is also commonly used in periodic predictive maintenance testing. The same concerns exist as for high potential testing.

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2.3. Surge Comparison Test

This type of test is the most common analysis tool for testing turn-to-turn insulation in motors and generators. In this test, a short pulse of high voltage energy at an appropriate stress level is sent through the windings and the results captured on a recording oscilloscope. The patterns of two identical circuits are then compared and the overlaying waves will highlight any differences which represent a potential failure point. A trained test technician can often identify winding failure types by the oscilloscope wave forms. This test is normally used in conjunction with a high potential test. This type of test is described in IEEE Standard 522. Modern automated winding analysis equipment combines many of these tests into a concise report and is very useful for predictive maintenance practices. Again, these high voltage tests should only be performed by a trained generator test technician.

2.4. Partial Discharge Testing

Both periodic and continuous monitoring testing of partial discharge currents and/or corona are common for large, high voltage machines for trending expected useful insulation life. Some techniques do exist for testing low voltage applications, but specialized equipment and training are necessary. It should be considered for long term predictive maintenance programs.

Summary

Good maintenance practice calls for the periodic evaluation of generator electrical conditions and should always be part of a basic maintenance plan. Use of the proper testing protocols can assure safe operation of the generator and can help highlight corrective opportunities before catastrophic failure. True predictive high voltage tests offer useful data for analysis and maintenance scheduling to avoid unplanned outages, but should only be performed by trained technicians.

References

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